UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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MEMORANDUM

SUBJECT: Risk Management Principles
San Jacinto River Waste Pits Superfund Site
Harris County, Texas

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DATE: August 22, 2016

The purpose of this memorandum is to address the criteria raised in the OSWER Directive "Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites" as they relate to the San Jacinto River Waste Pits Superfund Site (Site).

The following discussion addresses each of the principles for managing contaminated sediment risks articulated in the OSWER Directive. Please contact Gary Miller (214) 665-8318 or me at (214) 665-2706 if you need additional information, or have any questions or comments concerning this memorandum.

Risk Management Principles
San Jacinto River Waste Pits Superfund Site
Hidalgo County, Texas
August 22, 2016

1. Control Sources Early

A. Were all significant continuing sources of sediment contamination at the site identified? For each continuing source, were the plans to control these sources described, including the expected time to complete these actions, who will undertake them, and how any continuing sources are being monitored?

The San Jacinto Waste Pits site (site), located in Harris County, Texas (Attachment 1), is a former pulp and paper mill waste dump site built in the mid-1960s. It consists of the northern impoundments (approximately 14 acres) and a southern impoundment (less than 20 acres) divided by the Interstate-10 bridge as it crosses the river. Due to regional subsidence, the northern impoundments are now partially submerged in the tidally influenced San Jacinto River. The southern impoundment is located along side an industrial shipyard. Contaminated soils are the media of concern in the southern impoundment, and there is no evidence they are a source to the river. Therefore, this area will not be discussed further in this memo. Media of concern in the northern impoundments include both soil and sediment. The primary contaminants of concern include dioxins/furans. PCBs are also present on site, however, PCBs can be found throughout the San Jacinto River and Houston Ship Channel watershed. The Texas Department of State Health Services currently has fish advisories posted for both dioxins/furans and PCBs for the Houston Ship Channel, and the San Jacinto River all the way down to Galveston Bay into the Gulf of Mexico (ADV-49). Dioxins/furans can also be found throughout the entire watershed, however, the congener fingerprint of dioxins/furans on and immediately surrounding the site is dominated by 2378-TCDF and 2378-TCDD and is distinct from other areas. 2378-TCDF and 2378-TCDD are nearly absent from other locations which are dominated by 1234678-HpCDD, 1234678-HpCDF and OCDF. OCDD is present throughout the watershed at concentrations orders of magnitude higher than any of the other congeners. From 2010 to 2011, a time-critical removal action (TCRA) was implemented by the potentially responsible parties (PRPs) under an Administrative Order on Consent to cap the waste pits including submerged portions (Attachment 2). The armored cap consisted of layers of geotextile covered with varying sizes or rock. Effectiveness of the cap has been monitored by way of regular site inspections and porewater analyses. Porewater analyses have revealed that dioxin/furans are not leaking through the cap, however, physical inspections have periodically revealed the need for repair of rock cover in various locations.

B. Where there is uncertainty about the timing or effectiveness of source control actions, or if all sources can be controlled, did the memo indicate (1) how the potential for recontamination had been considered in the selection or development of the proposed sediment remedy, and (2) to what extent the proposed sediment remedy is expected to be beneficial if source control is not effective or not complete by the time the proposed sediment remedy is planned to be implemented?

As noted above, a geotextile and armored rock cap was constructed between 2010 and 2011 as a time-critical removal action. The purpose of this cap was to eliminate the immediate threat and stop the release of dioxins/furans from the waste pits into the river until selection of a permanent remedy. Since the San Jacinto River is a very dynamic waterway, prone to severe flooding and potential hurricanes, the cap was originally designed to withstand a 100-year flood event. Effectiveness of the cap has been monitored by way of porewater testing, and stability of the cap has been monitored by regular physical inspections. In 2012, SPMEs were deployed to assess porewater within the cap to determine whether or not it was effective at containing TCDD and TCDF and controlling any releases from the pits. Results indicated that TCDD and TCDF were below detection limits and that a concentration gradient was not apparent. Another assessment of porewater within the cap, surface water and fish tissue was scheduled for summer 2016 (data pending). Physical inspections of the cap have been performed regularly since its completion. In July of 2012, inspections revealed a small area of exposed geotextile on the northwest berm. The geotextile was intact, and rock was replaced. Independent review of TCRA Cap repair Plan by the US Army Corp of Engineers (USACE) revealed additional design change recommendations.

Although the armored cap is not the selected remedy, its effectiveness does come with uncertainties. See Question 5B for a list of cap deficiencies discovered since its construction.

The selected remedy appears to have the least amount of uncertainty associated with long-term recontamination – especially in the event of a major storm. Uncertainties with the selected remedy are mostly associated with potential release during implementation. Those will be addressed as best as possible by incorporating best management practices recommended by the US Army Corp of Engineers report, "Evaluation of the San Jacinto River Waste Pits Feasibility Study Remediation Alternatives (August 2016)".

2. Involve the Community Early and Often

A. Was the role of the community in the RI/FS or EE/CA and the mechanisms that were used to solicit effective involvement of a variety of community members described?

EPA in cooperation with Elected Officials, and State, County, and Local Agencies have been providing a steady program of community outreach and public participation for the Site since the Site was listed to the National Priorities List. EPA and the State first met with area agencies such as the Houston-Galveston Area Council to update plans for Site cleanup under the Superfund Program.

EPA and its partner agencies such as Harris County has provided a robust and comprehensive program of community involvement and public participation for the Site. They started with a World Café' initiative Community Meeting in 2010 to brief the public regarding the Site and share information on the Superfund process, the next steps, and how the community could get involved in this very technical remediation. As a result of intensive community interest, the Site was deemed a Community Engagement Initiative Site by EPA Headquarters which led to additional outreach planning such as informational meetings and mail outs to a large site mailing list.

This site was selected as one to be part of the Agency's Community Engagement Initiative pilot program. A World Café Meeting was conducted soon after. Starting in late 2010, the EPA initiated a Community Advisory Group for the Site known as the Community Awareness Committee which began a series of quarterly meetings at the Harris County Attorney's Office. In 2012, the EPA provided a Technical Assistance Grant to the Galveston Bay Foundation to hire a technical advisor to provide assistance. And, a number of local internet websites are being utilized to keep area citizens updated on site events.

EPA has since provided a number of Community Meetings, Open Houses, Elected Officials briefings, media interviews, Public Notices, and fact sheets to inform the public and keep residents updated on all Site developments that affect cleanup actions. Site fact sheets are available on the Site profile webpage.

B. *Did the memo briefly describe how local societal and cultural practices were identified and considered in (1) the human health risk assessment (e.g., local recreational use of the water body, local fishing practices) and (2) the selection or development of the proposed remedy (e.g., current and future uses of the water body)?*

The site is located in southeast Texas just upstream the Houston Ship Channel and flows into Galveston Bay. The site includes mixed residential and industrial to the west of the Site and undeveloped or residential areas to the east and north of the Site. Immediately south of the Site is commercial/ industrial land use. There are no surface water intakes within 15 miles downstream the site. The Texas Department of State Health Services reports that the San Jacinto River along with nearby Upper Galveston Bay, Tabbs Bay, and the San Jacinto State Park have "many points of public access and support both recreational and subsistence fishing activities" (TDSHS 2005a fr RI/FS workplan). However, published information the intensity and types of recreational activities as well as fish and shellfish harvesting activities within the immediate vicinity of the Site is limited, with only data consisting of general creel surveys for the greater Houston area by the Texas Department of Parks and Wildlife. Prior to the construction of the cap, the northern impoundments appear to have been a popular recreational area. Observed recreational activities included fishing, crabbing, swimming and wading. Recreational fishing is common throughout the area despite fish and crab consumption advisories posted by TDSHS, however the amount and frequency of fishing within site boundaries has not been determined. Commercial fishing is substantial throughout the Galveston Bay area. Although there is the possibility of subsistence fishing in the area, it was determined that subsistence fishing is not significant on the site. The following was provided by TDSHS by e-mail on June 24, 2016:

> *"The USEPA suggests that, along with ethnic characteristics and cultural practices of an area's population, the poverty rate could contribute to any determination of the rate of subsistence fishing in an area. The USEPA and the DSHS find it is important to consider subsistence fishing to occur at any water body because subsistence fishers (as well as recreational anglers and certain tribal and ethnic groups) usually consume more locally caught fish than the general population. These groups sometimes harvest fish or shellfish from the same water body over many years to supplement caloric and protein intake. People, who routinely eat fish from chemically contaminated water bodies or those who eat large quantities of fish*

from the same waters, could increase their risk of adverse health effects. The USEPA suggests that states assume that at least 10% of licensed fishers in any area are subsistence fishers. Subsistence fishing, while not explicitly documented by the DSHS, likely occurs in Texas. The DSHS assumes the rate of subsistence fishing to be similar to that estimated by the USEPA.

In the DSHS Public Health Assessment that was released in October 2012, one of the exposure scenarios was that of a subsistence fishermen. This was incorporated to account for the potential exposure pathway to children and adults that may be subsistence fishermen and consume fish caught from areas surrounding the SJRWP. The scenario used was:

Adults who fish 260 days/year for 30 years and children of subsistence fishers who are exposed from age 3 – 50 (47 years).
Through DSHS outreach activities, ***most of the people interviewed along the San Jacinto River, Houston Ship Channel, and Upper Galveston Bay have told DSHS that they are fishing and/or crabbing for recreational purposes****; however, some people do admit to consuming fish and/or crabs from these areas. One could assume that a small percentage of people found fishing in these areas could potentially be subsistence fishers but don't admit it."*

A significant portion of the population in the area speak Spanish or Vietnamese. During site investigations, many fishing advisory signs have been placed throughout the watershed to supplement those already present. Advisory signs are printed in English, Spanish and Vietnamese.

The TCRA included the armor cap, fencing, water buoys and additional fishing advisory signs around the northern impoundments. Fencing is intended to exclude visitors from accessing the site including former access points under the I-10 bridge. Buoys are intended to exclude water access surround the impoundments on the northern side. Due to continued access by visitors, fences are regularly inspected, buoys have been upgraded, and surveillance cameras have been installed on site. These cameras are monitored 24/7. The northern impoundment are an attractive nuisance to would be recreational visitors, and it is expected that implementation of the selected remedy will reduce the site's attractiveness and accessibility.

As noted, the site is located in highly industrialized area. This section of the San Jacinto River incurs heavy boat and barge traffic. Barges are known to dock at properties to the northwest, east, and at the Southern Impoundment area. Consequently, barge strikes are a concern for the site, especially during severe flooding events. It is expected that implementation of the selected remedy will reduce the potential for such strikes.

C. *Did the memo describe the major ways the proposed sediment remedy is expected to affect the local community, including impacts that occur during remedy implementation.*

The selected remedy is not expected to impact local water supplies. The San Jacinto River, in this area, is brackish and not suitable for drinking. Salinity fluctuates depending on river flow. Surrounding communities primarily use groundwater for drinking and irrigation purposes. Most private wells in the area are 100-300 feet deep which is much deeper than

contamination in the waste pits. Sampling results around the site and in surrounding communities reveals that dioxins/furans have not infiltrated groundwater.

The selected remedy is expected to remove or significantly reduce a popular recreational/fishing area. Much of the cap is expected to no longer be accessible by foot, but much of the surrounding shorelines will not be altered. A considerable amount of recreation, fishing and crabbing should still be possible. Despite this, the community seems overwhelmingly in favor of the selected remedy. The selected remedy does however, concern some downstream residents. The proposed remedy does have the potential to result in some release of dioxins/furans during remedial actions.

D. *Was the expected level of community support for the proposed sediment remedy discussed? Did the memo identify any aspects that are expected to be of most concern to the community and briefly describe how these concerns have been addressed or considered?*

As stated above, there appears to be overwhelming community support for the selected remedy. The following entities are in support of the proposed remedy:

- Local, State and Federal elected officials
- Local Agencies
  - Harris County Attorneys Office
  - Port of Houston
  - Letters from local schools
- Community based organizations
  - Coastal Conservation Association of Texas
  - Galveston Bay Foundation
  - San Jacinto River Coalition
  - Texans Together

There is also an organization, The San Jacinto Citizens Against Pollution, which is in opposition to the proposed remedy. This organization supports a permanent cap. Their primary concern is the potential for some release during remedial actions. The selected remedy will address these concerns as best as possible through, but not limited to, best management practices recommended in the US Army Corp of Engineers report, "Evaluation of the San Jacinto River Waste Pits Feasibility Study Remediation Alternatives (August 2016)".

3. Coordinate with States, Local Governments, Tribes, and Natural Resource Trustees

A. *Did the memo briefly describe the major sediment-related issues in which State and local governments have been involved at the site? If there were any aspects that are expected to be of most concern to State and local governments, did the memo describe how those concerns have been addressed or considered?*

Throughout the process, the EPA has coordinated extensively with the US Army Corp of Engineers (USACE), Texas Commission on Environmental Quality (TCEQ), the Texas Department of State Health Services (TDSHS), the Port of Houston Authority (PHA), and Harris County. Sediment-related issues most pertinent to State and local governments include TMDL development, fish consumption advisories, and dredging for navigation.

Region 6 has worked very closely with state agencies during all phases of work performed for this site. The TCEQ was instrumental in TCRA planning and design, and equally as involved during the remedial investigation. TCEQ was already drafting TMDLs for dioxins for the Houston Ship Channel and Upper Galveston Bay when the site was listed on the NPL. TMDL staff shared data and were key in helping develop the RI workplan. These TMDLs have yet to be finalized. The TDSHS has been involved in many aspects of community involvement, education, health consultation, and implementation of local fish consumption advisories. Fish consumption advisories for dioxins, PCBs and organochlorine pesticides have been in place for many years throughout the entire watershed. The advisory for organochlorine pesticides was recently lifted. TDSHS was also independently responsible for responding to the community's request for an epidemiological study of the area. While it was determined by an "expert panel" that a full epidemiological study was not feasible, TDSHS did release reports on occurrence of developmental effects and cancer rates in areas surrounding the site. EPA Region 6 had representation on the TDSHS "expert panel".

Region 6 has also worked very closely with the USACE regarding navigational dredging and disposal of dredge spoils. The site is surrounded by intense industry and shipping activities, and therefore, requires regular navigational dredging. Soon after listing, the EPA engaged the USACE in developing sampling, analysis, and decision criteria for any dredging permit applicant and their potential dredge spoils within several miles upstream or downstream of the site. As shipping activity and associated navigational dredging are also of importance to the local economy, these efforts also involved close consultation and coordination with the PHA. The special conditions set in place for new dredging permits near the site are still in place.

B. *For sites that include water bodies where Total Maximum Daily Loads (TMDLs) are being or have been developed, were the coordination efforts with the State and with EPA's water program described? Were any aspects of the TMDL development that were considered in selecting the proposed remedy discussed?*

As stated above, TMDL development for dioxins for the Houston Ship Channel and Upper Galveston Bay were already underway when the site was listed in 2008. By the start of the remedial investigation, TMDL development was near completion. The TMDL has yet to be finalized. Also stated above, EPA Region 6 worked closely with TCEQ TMDL development staff. TCEQ shared large amounts of data, some of which was incorporated in the RI. TCEQ TMDL development staff also played a large role in helping develop the RI workplan. It is clear that remediating the site could influence the final dioxins TMDLs for the area, however, the potential final TMDLs did not influence the choice for the selected remedy.

C. *If there are Tribal interests at the site, did the memo identify any aspects of the proposed sediment remedy that are expected to be of most concern to the Tribe(s) and how those concerns have been addressed or considered?*

There are no Tribal interests or concerns in this site.

D. *If there are Natural Resource Trustee interests at the site, did the memo identify the major areas of coordination related to the performance of the RI/FS or the ecological risk assessment? Were any Trustee restoration activities that may be concurrent with or follow the Superfund action and the extent to which those restoration activities are dependent on the Superfund action discussed?*

Early in the process, EPA coordinated extensively with Federal and State Natural Resource Trustees including US Fish & Wildlife Service (FWS), the National Oceanic and Atmospheric Administration (NOAA), the Texas General Land Office (GLO), and Texas Parks and Wildlife. These organizations were instrumental in TCRA planning and design as well as remedial investigation planning including ecological risk assessments. State Trustees provided valuable comments on all relevant documents through the ecological risk assessment, however, no comments have been received on the draft Feasibility Study or draft Proposed Plan. EPA is not aware of any restoration activities expected to be concurrent or following the remedial actions at the site.

3. Develop and Refine a Conceptual Site Model that Considers Sediment Stability

A. *Was a copy of the conceptual site model for sediment (e.g, one or more diagrams or charts) included in the memo? Did it identify all major contaminant sources, contaminants of concern, affected media, existing and potential exposure pathways, and human and ecological receptors that are at risk?*

Conceptual site models (CSM) were developed for human health and ecological risk at the beginning of the remedial investigation (RI). CSMs have been revised at multiple points during the RI. A copy of the CSMs for the northern impoundments are attached to this memo (Attachment 3). The two CSMs depict the source, the affected media, the existing and potential exposure pathways, and the human and ecological receptors that are potentially at risk.

B. *Did the memo identify the natural and man-made disruptive events or forces that were considered when evaluating sediment alternatives, including the recurrence interval or probabilities of those events or forces? Did it relate these forces to rates of erosion and sedimentation?*

Between 1851 and 2004, 25 hurricanes have made landfall along the north Texas Gulf Coast, seven of which were major (Category 3 to 5) storms. Tropical Storm Allison, which hit the Texas Gulf Coast in June 2001, resulted in 5-day and 24-hour rainfall totals of 20 and 13 inches, respectively, in the Houston area, resulting in significant flooding. More recently, Hurricane Rita made landfall in September 2005 as a Category 3 storm with winds at 115 miles per hour. In September 2008, the eye of Hurricane Ike made landfall at the east end of Galveston Island. Ike made its landfall as a strong Category 2 hurricane, with Category 5-equivalent storm surge, and hurricane-force winds that extended 120 miles from the storm's center.

In October 1994, heavy rainfall occurred in southeast Texas resulting in the San Jacinto River Basin receiving 15 to 20 inches of rain during a week-long period. One of the largest measurements of stream flow ever obtained in Texas, 356,000 cubic feet per second (cfs), was made on the San Jacinto River near Sheldon on 19 October 1994 at a

stage of 27 feet. During the measurement, velocities of water that exceeded 15 feet per second (about 10 miles per hour) were observed. Another storm occurring in 1940 had a river stage height of 31.5 feet at the same Sheldon location. The 100-year flood, which is defined as the peak stream flow having a one percent chance of being equaled or exceeded in any given year, was exceeded at 18 of 43 stations monitoring the area. For those stations where the 100-year-flood was exceeded, the flood was from 1.1 to 2.9 times the 100-year-flood.

The 1994 flooding caused major soil erosion and created water channels outside of the San Jacinto River bed. This flooding caused eight pipelines to rupture and 29 others were undermined at river crossings and in new channels created in the flood plain outside of the San Jacinto River boundaries. The largest new channel was cut through the Banana Bend oxbow just west of the Rio Villa Park subdivision, about 2½ miles northwest of the Site. This new channel was approximately 510-feet wide and 15-feet deep. A second major channel cut through Banana Bend just north of the channel through the oxbow. Both of these new channels were cut through areas where sand mining had been done before, as is the case in the vicinity of the Site. Sonar tests in a 130-foot section south of the I-10 Bridge located adjacent to the Site found about 10 to 12-feet of erosion from the bottom of the river bed.

As noted above, the northern impoundments are now partially submerged in the River due to regional subsidence. This location was a natural sandbar prior to the development of berms and the placement of waste. It is possible that this area would have been eroded away if not for the waste impoundments. In addition, this area of the San Jacinto River has been subject to sand mining. Areas immediately west of the impoundments have been mined. It is possible that some release from the northwest corner of the northern impoundments was caused by sand mining operations.

5. Use an Iterative Approach in a Risk-Based Framework

A. Did the memo briefly describe the major ways in which an iterative approach was used at the site? (An iterative approach is one that incorporates testing of hypotheses and conclusions and fosters re-evaluation of new information as it is gathered.).

The DQO process was used during the development of the work plan for the RI. This systematic planning process for evaluating environmental data uses an iterative process where the design for the study is optimized at various steps. Both the human health and the ecological risk assessments were conducted using a tiered approach. The first tier was used to establish the nature and extent of the contamination and to develop a list of COPCs. Following completion of the screening level assessments, the DQOs were revised as part of the problem formulation step.

Characterization of the primary physical and chemical processes that control the distribution and concentrations of COPCs at a site is gained through the iterative development and refinement of a CSM using site-specific information. The CSM is intended to provide a succinct depiction of the sources of COPCs, the physical-chemical processes that control chemical transport and fate over time and space, and the exposure pathways that may lead to exposure and adverse effects to ecological and human receptors.

TMDL data and data obtained by the TDSHS were evaluated for appropriateness for the RI and to determine data gaps prior to RI investigation sampling events. Recently, additional surface water and fish tissue data have been collected. Results are not available, but the data will be used appropriately.

B. *Did the memo describe any early or interim actions (other than the proposed remedy) planned or implemented at the site that address threats from contaminated sediment?*

On May 11, 2010, EPA filed the Administrative Settlement Agreement and Order on Consent for a Removal Action. The Administrative Settlement Agreement and Order on Consent for Removal Action provided for the performance of a time critical removal action (TCRA). The TCRA refers to the armored cap which has been discussed throughout this document.
The EPA Action Memorandum required that the TCRA stabilize the northern impoundments to withstand forces sustained by the river, including a cover design that considered storm events with a return period of 100 years, and prevent direct human and benthic organism contact with waste materials. Elements of the selected TCRA included construction of a perimeter fence on the uplands to prevent unauthorized access; placement of warning signs around the perimeter of the northern impoundments and on the perimeter fence; design and implementation of an operations, monitoring, and maintenance plan; and installation of an armored cap with the following items:

- A stabilizing geotextile underlayment over the northern impoundment eastern cell
- Treatment through stabilization and solidification of a portion of the northern impoundment western cell
- An impervious geomembrane underlayment in the northern impoundment western cell
- A granular cover over the northwestern area of the northern impoundment western cell
- A granular cover above the geotextile and geomembrane in the northern impoundment western cell
- A granular cover above the geotextile in the northern impoundment eastern cell.

Construction activities were completed in July 2011. The Operations, Monitoring, and Maintenance Plan identifies continuing obligations, including monitoring and maintenance, with respect to the TCRA. TCRA inspection events include: 1) visual inspection of the security fence, signage and the armored cap, 2) collection of topographic survey data for the portions of the armored cap that are located above the water surface, 3) collection of bathymetric survey data for the portions of the armored cap that are below the water surface, and 4) manual probing of armored cap thickness at areas identified by the topographic or bathymetry surveys as more than 6 inches lower in elevation than during the prior survey. Inspection and repair reports, as needed, are submitted to EPA. The Operation, Monitoring, and Maintenance Plan has been modified because the regular previous inspections failed to identify deficiencies in the cap.

Since its completion in July 2011, the armored cap has generally isolated and contained impacted material. The following cap deficiencies have been documented since the time of armored cap installation:

- **July 2012:** Approximately 200 ft^2 of geotextile exposed (armor materials had moved down slope)
- **January 2013:** Five areas deficient in cap thickness and/or have exposed geotextile
- **December 2016:** Approximately 550 ft^2 of cap missing or deficient in cover (no geotextile, paper mill waste exposed to the river, and a sediment concentration measured at 43,700 ng/kg $TEQ_{DF,M}$)
- **February 2016:** portions of eastern cell exposed (five areas, approximately 3 ft^2 each, of exposed geotextile)
- **March 2016:** more than 15 additional portions of eastern cell deficient in armor cover thickness.

C. *If the proposed sediment remedy will be implemented in phases or if it is part of a larger phased approach to the site as a whole, were the phases clearly described?*

It is possible, but not fully determined, that a phased approach will be used for implementation of the proposed remedy other than the likelihood that remedial actions for the northern impoundments will be separate from those of the southern impoundment. This may be more of a remedial design question. The removal will be completed in stages or sections as appropriate to limit the exposure of the uncovered sections of the waste pits to potential storms. It has been discussed that remedial actions in the northern impoundments may best be served by implementing removal to a small portion of the site first. Data gathered during that removal will then be used to guide excavation and best management practices moving forward.

6. **Carefully Evaluate the Assumptions and Uncertainties Associated with Site Characterization Data and Site Models**

A. *Did the memo briefly describe the most important uncertainties associated with characterizing site conditions? Where mathematical models were used, were the uncertainties around the important input parameters (e.g., those used to the estimate human health and ecological risk and the predicted effectiveness of potential sediment remedies) discussed? Did the memo briefly explain how those uncertainties were accounted for (e.g., use of sensitivity analyses or reasonable conservative assumptions)?*

As with most sites of this complexity, many uncertainties are evident and had to be addressed. Some, uncertainties were accounted for by way of sensitivity analyses (mainly in the risk assessments), use of conservative assumptions and/or additional data collection and study. Some important uncertainties regarding site characterization include:

- COPC selection due to industrial nature of surrounding areas
- High detection limits for sediment data/non-detect data: Non-detects were replaced with half-detection limit.
- Aroclor versus PCB congeners data: Aroclors were mostly non-detect on site, so congener data were used for site characterization.
- Dioxins/furans source contribution to the site: Many sources of legacy dioxin/furan contamination exist in the area. Fingerprinting exercises based on

congener ratios were used to aid in differentiation of sources to the site and surrounding areas. An "unmixing analysis" was also performed.

- Movement of contaminants in the groundwater: Concerns of dioxin contamination moving through the groundwater under the pits into the river and from soils in the southern impoundment into the river were addressed through groundwater sampling and data analysis.
- Fate and transport modeling: Three linked models were used to simulate hydrodynamics, sediment transport and chemical fate and transport. Models used laboratory and site-specific data to the greatest extent possible. Sensitivity analyses were performed for the chemical fate models.
- Storm and flooding models to support TCRA cap design and remedial alternatives: In order to design the TCRA cap to withstand a 100-year flood, the PRPs used the above models to simulate storm/high flow events. The USACE used the LTFATE multi-dimensional modeling system to assess the integrity of the TCRA cap and also to simulate different potential storm/flood event scenarios as an aid to evaluate remedial alternatives. Uncertainties associated with the LFATE model as used for the site are described in the USACE report, "Evaluation of the San Jacinto River Waste Pits Feasibility Study Remediation Alternatives (August 2016)".
- Bioaccumulation modeling: Dioxin/furan congeners do not consistently bioaccumulate in fish or invertebrate tissue. In addition, bioaccumulation appears highly variable among species. Systematic predictions of bioaccumulation from concentrations of dioxins and furans in abiotic media (both sediment and water) are only possible for some congeners and are associated with high uncertainty. These limitations are partly due to variability in uptake efficiencies for different congeners, from various exposure media, through different exposure routes, and by different species. The ability of organisms to transform and eliminate the different congeners, and the differences in transformation and elimination rates for different congeners added complexity to patterns of dioxin and furan bioaccumulation across the range of taxa evaluated for the RI. Uncertainties in model predictions suggest that it should not be assumed that tissue concentrations of dioxins and furans in tissue will be reduced in a linear fashion to correspond with reductions in sediment concentrations.
- Risk assessments: Most uncertainties in risk assessments stem from the exposure point concentration and the use of particular exposure parameters. For the BHHRA, the Reasonable Maximum Exposure (RME) was used in developing remedial goals. Probabilistic risk assessment techniques were also employed for some exposure scenarios. Ecological risk assessments are inherently imprecise and uncertain, and any ecological risk analysis provides only a simplified model of a natural environment that is complex and dynamic. Three main areas of uncertainty in the ERA are data gaps and limitations, model uncertainty and toxicity information. Best available literature values and conservative assumptions were used where appropriate.

B. *If a new mathematical model was used, or if a model at a large or complex site was calibrated using site data, did the memo describe the peer review process used for the model and briefly summarize the results of the peer review?*

Established methods for calculating food chain risks were used in the human health and ecological risk assessments. Known models were also used to assess the fate and transport of sediments in the area as well as for determining TCRA design for a 100-year flood and independent evaluation of remedial alternatives.

7. Select Site-specific, Project-specific, and Sediment-specific Risk Management Approaches that will Achieve Risk-based Goals Approaches that will Achieve Risk-based Goals

A. Did the memo list all alternatives that were evaluated for remediation of contaminated sediment at the site? If this list did not include some form of each of the three major sediment cleanup methods (i.e., capping, monitored natural recovery, dredging, and/or combinations of these), did the memo explain why the method was not evaluated?

Currently, the Alternatives considered for the northern impoundments include the following. These alternatives include all the options listed in the CSTAG memo guideline.

- 1N – Armored Cap and Ongoing Operations, Monitoring, and Maintenance (No Further Action)
- 2N – Armored Cap, Institutional Controls, Ground Water Monitoring, and Monitored Natural Recovery
- 3N – Permanent Cap, Institutional Controls, Ground Water Monitoring, and Monitored Natural Recovery
- 4N – Partial Solidification/Stabilization, Permanent Cap, Institutional Controls, Ground Water Monitoring, and Monitored Natural Recovery
- 5N – Partial Removal, Permanent Cap, Institutional Controls, Ground Water Monitoring, and Monitored Natural Recovery
- 5aN – Partial Removal of Materials Exceeding Cleanup Levels, Permanent Cap, Institutional Controls, Ground Water Monitoring, and Monitored Natural Recovery
- 6N – Full Removal of Materials Exceeding Cleanup Levels, Institutional Controls, and Monitored Natural Recovery

Enhancements to some of the above alternatives are currently being considered.

B. Did the memo describe the proposed sediment remedy for the site and how it relates to any other sediment operable units at the site?

The preferred remedy for the northern impoundments is Alternative 6N, which calls for full removal and offsite disposal of materials exceeding preliminary cleanup goals and Institutional Controls. This alternative entails excavation of approximately 200,100 cubic yards of sediment from the TCRA footprint and the area near the upland sand separation area, which would require a relatively large offloading and sediment processing facility to efficiently accomplish the work, which would require barge unloading, sediment re-handling, dewatering, stockpiling, transloading, and shipping to the offsite landfill facility. Additional activities would include management and disposal of dewatering effluent, including treatment if necessary. Soil that is removed would be transported in

compliance with applicable requirements and permanently managed in a permitted landfill cleared by the EPA's regional offsite rule cont

Contaminated sediments within the footprint of the cap itself will be removed to a depth/concentration of 200 ng/Kg. Two layers of clean fill will be placed atop of that area after excavation. The cleanup goal for the remaining sediments within the site perimeter will be 30 ng/Kg for the protection of human health through fish consumption. Most concentrations outside the footprint of the pits are already below 10 ng/Kg, and a site-wide average outside the footprint of the pits is expected to already be below 30 ng/Kg.

C. *Did the memo clearly explain the rationale for the proposed remedy, and does it make sense based upon the information in the Proposed Plan?*

Based on the information available at this time, EPA believes that the Preferred Remedy is protective of human health and the environment, complies with ARARs, and provides the best balance of tradeoffs among the balancing criteria. It reduces risks within a reasonable time frame, provides for long-term reliability of the remedy, and minimizes reliance on institutional controls. It will achieve substantial risk reduction by removing the most contaminated materials, reduces remaining risks in the aquatic environment to the extent practicable, and manages the remaining risks to human health through institutional controls.

EPA considered several options for contaminated materials. EPA's preferred remedy includes full removal of contaminated materials above cleanup levels for the following reasons:

- The material is highly toxic and under baseline conditions may be highly mobile in a severe storm and therefore is considered a principal threat waste.

- The location of materials, either partially submerged within the San Jacinto River (northern impoundments) or on a small peninsula on the San Jacinto River (southern impoundment), result in limited ability to treat the waste in place without the threat of a release during the remedial action.

- The area has a high threat of repeated storm surges and flooding from hurricanes and tropical storms, which, if the material was left in place, could result in a release of hazardous substances. Flooding events also bring a significant threat of barge strikes and are expected to worsen due to climate change.

- The history of armor cap maintenance required as a result of floods much less than the design 100-year flood.

For all of these factors, the Preferred Remedy provides greater permanence in comparison to other alternatives. Less costly alternatives rely on remedies that have a higher chance of failure by leaving principal threat waste source materials in the river, resulting in greater uncertainty as to their long-term effectiveness.

8. Ensure that Sediment Cleanup Levels are Clearly Tied to Risk Management Goals

A. Did the memo briefly summarize the risks associated with contaminated sediment that were identified in the human health and ecological risk assessments?

The baseline human health risk assessment (BHHRA) assessed risks based on conditions prior to the placement of the TCRA armored cap. It identified potential concerns for human health from direct contact, including incidental ingestion of soil and sediment as well as potential risks associated with ingestion of fish (hardhead catfish) or shellfish (clams and crabs) from the site. The BHRRA assessed cancer risks, non-cancer hazards, and cancer hazards (a method that assumes a threshold dose and uses an RfD) for dioxins/furans only. Risk-based decisions relied on non-cancer hazard indices because the associated RfD was obtained from a Tier I source, whereas the oral cancer slope factor comes from a Tier III source.

Of the COPCs identified for evaluation in the BHHRA, dioxins and furans were identified as a risk driver in all media evaluated. PCBs in fish and shellfish tissue, and methylmercury in catfish tissue were additionally identified as COPCs that contribute substantially to potential risks.

Hypothetical recreational visitors and hypothetical recreational fishers coming into direct contact with sediments within the area in the immediately vicinity of the pits (Beach Area E) and ingesting fish or shellfish from the adjacent Fish Collection Area (FCA) were found to have the highest risk. These scenarios represented the most conservative scenarios and subsequent calculation of preliminary remediation goals. Hypothetical recreational visitors who contacted sediments in this area were assumed to also contact soils at other locations throughout the TxDOT ROW and area north of I-10. Reasonable maximum exposure (RME) noncancer HIs greater than 1 were estimated for the these scenarios:

- Recreational Fisher; Beach Area E; Catfish from FCA 2/3 = 65
- Recreational Fisher; Beach Area E; Clam from FCA 2 = 64
- Recreational Fisher; Beach Area E; Crab from FCA 2/3 = 63
- Recreational Visitor; Beach Area E = 66

The baseline ecological risk assessment (BERA) also assessed risks based on conditions prior to the placement of the armored cap. A conservative assessment of risks to benthic invertebrates indicates no risks to the assessment endpoint of the abundance and diversity of benthic macroinvertebrate communities from exposure to BEHP, phenol, cobalt, copper, lead, thallium, and zinc. Concentrations of mercury exceed a conservative sediment quality guideline in two locations within the original 1966 impoundment perimeter, but these exceedances do not equate to a prediction of effects. If effects exist at these two locations, the affected areas are isolated and small, and do not adversely affect the assessment endpoint. Concentrations of 2,3,7,8-TCDD in sediments are not sufficiently high to negatively impact the benthic macroinvertebrate community.

Clam tissue concentrations of 2,3,7,8-TCDD were sufficiently elevated in samples collected directly adjacent to the northern impoundments to indicate reproductive risks to individual molluscs in that area. Concentrations of 2,3,7,8-TCDD in clam tissue from two

of five samples directly adjacent to the upland sand separation area exceed a threshold of histological effects and impaired reproduction in individual female oysters. These localized effects do not adversely affect the assessment endpoint – stable or increasing populations of bivalves within the Site – because the affected area is limited to the immediate vicinity of the northern impoundments.

Assessment of baseline risks to fish considered the concentrations of cadmium, copper, mercury, and zinc in the media ingested by fish; the concentrations of BEHP and nickel in water; and the concentrations of total PCBs, $TEQ_{DF,F}$, $TEQ_{P,F}$, and $TEQ_{DFP,F}$ (TEQ=toxicity equivalents quotient; DF=dioxins/furans; P=dioxin-like PCBs; F=using toxicity equivalence factors for fish) in whole fish. Results indicate negligible baseline risks to the assessment endpoint – stable or increasing populations of benthic omnivorous fish, benthic invertivorous fish, and benthic piscivorous fish within the Site perimeter.

Baseline risks are negligible (HQ<1) to the assessment endpoint of stable or increasing populations of great blue heron and neotropic cormorant, and the birds in their feeding guilds that are represented by these receptor surrogates and that could use areas within the Site perimeter. Baseline risks to terrestrial invertivorous birds such as the killdeer are also negligible for all COPCs except zinc and dioxins and furans. Probabilistic risk analysis showed a low probability (8.3 percent) that exposure of killdeer to zinc could exceed levels affecting reproduction for individual birds, indicating negligible risk to the assessment endpoint of stable or increasing populations of terrestrial invertivorous birds. A low probability (4.7 percent) was also shown that exposure of individual killdeer to $TEQ_{DF,B}$ (B=toxicity equivalence factors for birds) within the Site perimeter could exceed the Lowest observed adverse effect level (LOAEL). Baseline risks to spotted sandpiper and similar shorebirds, which ingest substantial amounts of sediment as a result of their foraging habit, are negligible for all COPCs except for dioxins and furans. Exposure of individual spotted sandpipers and the species it represents to dioxins and furans was found to have a 13.7 percent probability of exceeding exposures associated with reproductive effects.

Baseline risks to raccoon and mammals in the same feeding guild that could use the area within the Site perimeter were negligible. There is negligible risk to the assessment endpoint of stable or increasing populations of omnivorous mammals from any COPC. Baseline risks to the marsh rice rat, representative of aquatic mammals, are also negligible for all COPCs except dioxins and furans. Probabilistic risk analysis predicted a 14.3 percent probability that an individual marsh rice rat using the area within the Site perimeter under baseline conditions could be exposed to TEQDFP,M (M=toxicity equivalence factors for mammals) at levels exceeding those associated with reproductive effects on mammals. Given the spatial bias in the dataset towards areas containing the sediment with the highest dioxin and furan concentrations within the Site perimeter, and given that these rodents can rear more than one litter each year, and that the probability of exposure at the effects level is low, baseline risks to the assessment endpoint of stable or increasing populations of omnivorous mammals within the Site perimeter are negligible.

B. *Did the memo describe the remedial action objectives (RAOs) or removal objectives that were developed to address these risks?*

A summary of the RAOs are:

1) Eliminate loading of dioxins and furans from the former waste impoundments north and south of I-10 to sediments of the San Jacinto River.
2) Reduce human exposure to dioxins and furans from consumption of fish by remediating paper mill waste and impacted sediments to appropriate cleanup levels.
3) Reduce human exposure to dioxins and furans from direct contact with paper mill waste, soil, and sediment by remediating affected media to appropriate cleanup levels.
4) Reduce exposures of benthic invertebrates, birds, and mammals to paper mill waste-derived dioxins and furans by remediating media affected by paper mill wastes to appropriate cleanup levels.

C. *Did the memo describe the sediment cleanup and/or action levels, and briefly describe how they were derived, how they relate to the RAOs or removal objectives, and when they are expected to be met?*

Preliminary remediation goals (PRGs) were developed for the protection of human health from direct contact (including incidental ingestion) of sediments and consumption of fish or shellfish in areas surrounding the Site (also see above discussion on summary of risks, question 8A). The following PRGs were derived from the most conservative risk estimates:

- **200 ng/Kg** $TEQ_{DF,M}$ in the paper mill waste source areas based on the child recreational visitor exposure scenario.
- **30 ng/Kg** $TEQ_{DF,P,M}$ in surrounding river sediments based on the child recreational fisher exposure scenario.
- **0.0797 pg/L** $TEQ_{DF,M}$ which is the Texas Surface Water Quality Standard for Dioxins/Furans.
- **240 ng/Kg** $TEQ_{DF,M}$ for soils in the southern impoundment based on a construction worker exposure scenario (not relevant to this document and discussions of sediment).

If the PRGs are achieved in the identified areas, then the RAOs will be met. Each sediment PRG is based on the most conservative of risk estimates corresponding to each exposure scenario. Therefore, achieving these PRGs will accomplish the RAO for the waste pits and any of the surrounding area within the Site perimeter. Achieving the PRGs and RAO #s 1, 3 and 4 is expected to take approximately 16 months, however, RAO #2 – Reduce human exposure to dioxins and furans from consumption of fish by remediating paper mill waste and impacted sediments to appropriate cleanup levels – will take an undetermined amount of time longer. As stated above, many areas within this watershed have varying degrees of dioxin and PCBs contamination. The proposed remedy will certainly make a significant difference in localized fish contamination, however, it will take time for those concentrations to come down. It is worth noting that hardhead catfish tissue concentrations are already only slightly above background. Fish in the area will continue to receive contamination from other sources, and fish consumption advisories are not expected to be lifted.

9. Maximize the Effectiveness of Institutional Controls and Recognize their Limitations.

A. *Did the memo identify any institutional controls that are part of the proposed sediment remedy, and if so, describe how they will be implemented and any plans to maximize their effectiveness (e.g., public education regarding fish consumption advisories)?*

Institutional controls (ICs) will be used to prevent disturbance of the dredge residuals below the cover layers in the remediated areas. EPA Region 6 intends to discuss and coordinate possible ICs with other agencies (e.g., USACE and PHA). As such, specific ICs and the details of their implementation have not yet been fully determined. Some ICs being considered include, but are not limited to:

- Continued use Fish Consumption Advisory signage
- ICs to minimize effects of barge traffic in the area
- ICs to possibly prevent dredging in or near the footprint of the pits
- ICs to alert property owners of the presence of remaining subsurface material exceeding PRGs, if necessary
- Proprietary controls

B. *Did the memo briefly describe any plans for monitoring or information collection at the site which will be used to evaluate the effectiveness of institutional controls?*

EPA Region 6 intends to discuss and coordinate possible ICs with other agencies (e.g., USACE and PHA). As such, specific information or monitoring activities and their details of implementation have not yet been fully determined.

10. Design Remedies to Minimize Short-term Risks While Achieving Long-Term Protection.

A. *For in-situ capping alternatives, did the memo describe the measures that will be taken to minimize contaminant releases during cap placement, and the expected impact of cap materials on the recolonization of the cap by biota?*

Although an armored cap is not the selected remedy, the following quality control measures were followed during TCRA cap construction:

- Geotextile was placed over the Eastern and Western Cells prior to placing imported fill materials for the armored cap.
- Armored Cap materials were placed from the toe of the slope up towards the crest for slopes steeper than 10 horizontal to 1 vertical (10H:1V).
- Drop height of rock was monitored so as to minimize disturbance of sediment surface
- Armored Cap material was placed in controlled lift thicknesses to minimize disturbance and mixing of the Armored Cap material and sediment
- A turbidity curtain was placed around water-based rock placement and visually inspected for turbidity outside the curtain throughout activities
- Water quality monitoring was used to monitor for re-suspension of sediment

In addition, the Removal Action Workplan Health and Safety Plan provided the following ensurances in the event of an environmental release:

- Waste was to be collected and contained
- Containers of waste were to be removed or isolated from the immediate site of the emergency
- Treatment or storage of the recovered waste, contaminated soil or surface water, or any other material that results from the incident or its control was to be provided
- No waste that is incompatible with released material was to be treated or stored in the facility until cleanup procedures were completed
- All emergency equipment used was to be decontaminated, recharged, and fit for its intended use before operations resumed.

Cap placement has already shown to have only short-term impacts on resident biota. Sedimentation and recruitment of infauna has already occurred to some degree on the portion of the TCRA cap that is submerged. Organisms (e.g., small fish and bivalves) have been observed during recent cap inspections. Aquatic habitat surrounding the footprint of the pits continues to support aquatic wildlife (e.g., fish, bivalves, crabs, herons) and will contribute significantly to recolonization of the submerged portions of a cap.

B. *For dredging alternatives, did the memo briefly describe the measures that will be taken to minimize contaminant releases and sediment resuspension during dredging? Did it describe how and when the dredged habitat is expected to recover? If on-site disposal is planned, did it briefly describe the disposal unit and monitoring that will be required to assess protectiveness?*

The selected remedy is better defined as excavation rather than dredging. The selected remedy (full removal) will utilize Best Management Practices (BMPs) to reduce the re-suspension of sediment and release to the river. The removal will be completed in stages or sections as appropriate to limit the exposure of the uncovered sections of the waste pits to potential storms. Raised berms, sheet piles (possibly caissons), and silt curtains in addition to dewatering and removal in the dry to the extent practicable will be used to reduce the re-suspension and spreading to the removed material. The berms would be armored on the external site with armor material removed from the areas that have geotextile present. The design approach for removal and design of BMPs will be determined in the Remedial Design. Residual concentrations of contaminants following excavation and dredging will be covered by at least two layers of clean fill to limit intermixing of residual material with the clean fill. Cap rock, geomembrane, and geotextile from the existing armored cap, which currently isolates and contains impacted material, would be removed prior to beginning excavation.

Excavated sediment would be dewatered and stabilized at the offloading location, as necessary, to eliminate free liquids for transportation and disposal. Some operations, such as water treatment, may be barge mounted. Following removal of impacted sediment, the area from which sediments are removed will be covered with at least two residuals management layers of clean sediment to reduce intermixing. Institutional controls will be used to prevent disturbance of the dredge residuals below the cover layers in the remediated areas.

Habitat recovery should not take long at this site. Sedimentation and recruitment of infauna has already occurred to some degree on the portion of the cap that is submerged. Organisms (e.g., small fish and bivalves) have been observed during recent cap inspections. Aquatic habitat surrounding the footprint of the pits continues to support aquatic wildlife (e.g., fish, bivalves, crabs, herons) and will contribute significantly to recolonization of the pits area once remediated.

On-site disposal is not a component of the selected remedy.

C. Did the memo briefly describe the major expected effects of the proposed remedy on societal and cultural practices and how these were considered in remedy selection?

The proposed remedy will have minor impacts on societal practices, but it is expected that cultural practices will not be affected (see Question 2C).

11. Monitor During and After Sediment Remediation to Assess and Document Remedy Effectiveness.

A. Did the memo briefly describe the type of monitoring that will be required to assess contaminant releases during remedy implementation (i.e., during dredging, during cap placement, or during the recovery period in the case of monitored natural recovery)?

As discussed above, best management practices recommend by the USACE will be followed during implementation of the selected remedy. The BMPs themselves will be monitored to ensure that they are functioning as designed. Associated monitoring activities will be developed during the Remedial Design, but may include:

- Water quality monitoring to detect potential impacts on water quality and trigger the implementation of additional BMPs or an interruption of construction activities if necessary.
- Collection of fish or shellfish tissue and evaluation of data
- Collection of sediment and evaluation of data
- Collection of groundwater and evaluation of data
- Weather monitoring

B. For each medium (e.g., sediment, surface water, biota) that has a cleanup level or remedial action objective listed in the answer to #8A above, did the memo briefly describe the type of monitoring (including physical, biological, and chemical monitoring) that will be required to determine whether the levels and objectives are met? If sufficient baseline data were not available, were plans for collecting additional data prior to implementing the remedy described?

Each RAO is tied to soil or sediment. As such, confirmation sampling of soil and sediment in cleanup areas will occur during remedial actions. Concentrations of dioxins/furans will be monitored in these media. It is also likely that some fish tissue sampling will occur. Specific monitoring activities will be determined in Remedial Design, but may include:

- Water quality monitoring

- Sediment monitoring
- Soil monitoring
- Fish and/or shellfish tissue monitoring

Baseline data are sufficient for decisions moving forward with the selected remedy, however, additional data may be required during remedial actions. As stated above, it has been discussed that remedial actions in the northern impoundments may best be served by implementing removal to a small portion of the site first. Data gathered during that removal will then be used to guide excavation and best management practices moving forward.

C. *Did the memo briefly describe other plans for long term monitoring (e.g., monitoring of long-term success of source control measures, effects of disruptive events, migration of buried contaminants, cap integrity)?*

Specific long-term monitoring activities will be developed during Remedial Design. Since this area is prone to high flood events and the potential for major storms, monitoring after disruptive events is likely to be a major consideration. Long-term monitoring activities may include, but are not limited to:

- Water quality monitoring
- Sediment monitoring
- Bathymetric surveys after high flow or flooding events
- Fish and/or shellfish tissue monitoring

Cap integrity does not apply with the selected remedy, however, monitoring of areas that receive clean fill may be recommended.